

探索更绿色、更智慧的轨道交通技术

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城市的连接与发展离不开交通,我国轨道交通已进入高质量快速发展阶段。国务院在“十四五”期间印发了《国家综合立体交通网规划纲要》,提出建成现代化高质量国家综合立体交通网。同时,在“碳达峰、碳中和”的目标下,综合交通运输要率先达到碳达峰。轨道交通装备行业将立足于绿色、智慧、便捷的发展理念,进行技术创新布局,为生态友好型现代化交通提供更多的解决方案。

轨道交通是绿色交通。从动力驱动方式来看,轨道交通的发展经历了畜力驱动、蒸汽机驱动、内燃机驱动、电气化驱动等阶段,目前已迈入混合驱动的新阶段。电动化、氢能化是今后的发展趋势,其特色鲜明,以此最终实现交通载运装备动力能源系统的低碳化或净零排放,从而达到交通系统的绿色化目标。为了实现这一目标,研发工作应该从以下四个方面展开:

一是要研发智能的新型能源系统。我国风、光等可再生能源丰富,轨道交通基础设施和沿线空间具有充足的空间资源可用于可再生能源的开发利用。轨道交通行业正在研究车辆与车辆、车辆与地面协同的能源管理技术:新能源供电、储能、与现有供配电系统融合技术;基于新能源发电、牵引供电、配电等多维信息融合的绿色智能能源系统;能源能量流动控制策略和能量管理技术,实现轨道交通供电系统与新能源供电系统的互联互通、能量调控。

二是要扩大清洁能源的应用。实验研究表明,以氢能驱动列车具有较高的技术可行性,比如已经研制成功的氢能源有轨电车、储能有轨电车及氢能源公共交通工具。未来还将研制氢能源地铁。有资料显示,到2025年,我国加氢站将超过1000座,燃料电池汽车累计推广量将超过15万辆。

三是要推广新技术、新材料的应用。从车辆本身来说,研究轻量化技术,实现装备的小型化、集成化,进而实现低能耗。新材料方面,研究采用碳化硅的新型元器件、永磁等新型材料的牵引设备。目前,装用永磁新材料的永磁高铁、永磁地铁车辆都已研制成功,其平均综合能耗降低了7%~10%。

四是要重视能源回收。目前正在开展液氢储运和车载液氢系统技术方案制订和样机研制,探索碳回收、储藏、利用等负碳技术。

未来轨道交通的另一标志就是绿色交通和智慧交通的融合。为此就要建立完善的综合交通大数据系统,开展大数据、云计算、移动互联、人工智能等新技术在综合立体交通网建设中的应用研究。通过全面感知、深度互联、智能融合等新技术,建设信息共享、资源协调、优势互补的网联化、协同化、智慧化立体综合交通系统,实现同一交通方式中各系统要素之间相互协调,不同交通方式之间互联互通、综合协同。智慧交通将使民众出行变得高效和便捷。“信息一键式发布和乘客一站式服务”将极大提升公众“人享其行”的出行感受。

智慧交通的另一个标志就是运载工具快速向智能化方向转型。在更智能方向上,轨道交通列车将融合和人工智能等新技术;将通过多系统耦合、多参量作用的数字孪生技术以及全生命周期的智能化模式,构建列车智慧大脑,实现列车自感知、自组织、自决策。此外,无人驾驶、遥驾驶、空地一体化立体交通等新型交通系统必将不断涌现,并逐渐进入公众的日常生活。



Exploring Greener and Smarter Rail Transit Technologies

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Transportation is indispensable for urban development and connectivity, and China's rail transit has entered a stage of high-quality rapid development. During the '14th Five-Year Plan' period, the State Council issued the 'Outline of the National Comprehensive Three-dimensional Transportation Network Plan', proposing to build the modern high-quality national comprehensive three-dimensional transportation network. At the same time, under the goal of 'carbon peaking and carbon neutrality', comprehensive transportation should achieve carbon peaking first. The rail transit equipment industry will adhere to the development concept of greenness, smartness, and convenience, innovate technically, and provide more solutions for eco-friendly modern transportation.

Rail transit is green transportation. From the perspective of power drive modes, the development of rail transit has gone through stages of animal-drawn, steam-powered, internal combustion engine-powered, and electrified traction. It has now entered a new stage of hybrid drive. Electrification and hydrogenation are the future trends, characterized by achieving low-carbon or net-zero emissions of transportation equipment power energy systems, ultimately realizing the greening of transportation systems. To achieve this goal, research and development should focus on the following four aspects:

First, develop intelligent new energy systems. China has abundant renewable energy such as wind and solar power, and rail transit infrastructure and along-line spaces have sufficient resources for the development and utilization of renewable energy. The rail transit industry is researching vehicle-to-vehicle and vehicle-to-ground collaborative energy management technologies; new energy supply, storage, and integration technologies with existing power supply and distribution systems; green intelligent energy systems based on multi-dimensional information integration of new energy power generation, traction power supply, and power distribution; energy flow control strategies and energy management technologies to achieve interoperability and energy regulation between rail transit power supply systems and new energy power supply systems.

Secondly, expand the application of clean energy. Experimental studies show that hydrogen-powered trains have high technical feasibility, such as hydrogen-powered trams, energy storage trams, and hydrogen-powered public transportation vehicles that have been successfully developed. In the future, hydrogen-powered metros will also be developed. According to data, by 2025, China will have more than 1,000 hydrogen refueling stations, and the cumulative promotion of fuel-cell vehicles will exceed 150,000 units.

Thirdly, promote the application of new technologies and new materials. In terms of vehicles themselves, research on lightweighting technologies is crucial to achieve miniaturization and integration of equipment, thereby achieving low energy consumption. In terms of new materials, research on the use of new components such as silicon carbide and traction equipment made of new materials such as permanent magnets is essential. Currently, permanent magnet high-speed trains and permanent magnet metro vehicles equipped with permanent magnet new materials have been successfully developed, reducing average comprehensive energy consumption by 7% to 10%.

Fourthly, place emphasis on energy recovery. Currently, technical schemes for liquid hydrogen storage and transportation and the development of on-board liquid hydrogen systems are being conducted to explore carbon recovery, storage, utilization, and other negative carbon technologies.

Another hallmark of future rail transit is the integration of green and smart transportation. For this purpose, it is necessary to establish a comprehensive transportation big data system and conduct research on the application of new technologies such as big data, cloud computing, mobile internet, and artificial intelligence in the construction of the comprehensive three-dimensional transportation network. Through new technologies such as comprehensive perception, deep interconnection, and intelligent integration, an interconnected, coordinated, and intelligent comprehensive transportation system that shares information, coordinates resources, and complements advantages is established, thereby achieving mutual coordination among various system elements within the same mode of transportation means, and interoperability and comprehensive synergy among different modes of transportation means. Smart transportation will make people's travel more efficient and convenient. 'One-click information release and one-stop passenger service' will greatly enhance the public's travel experience of 'enjoying their journey'.

Another hallmark of smart transportation is the rapid transformation of vehicles towards intelligentization. In a more intelligent direction, rail transit trains will integrate new technologies such as artificial intelligence. Through the digital twin technology with multi-system coupling and multi-parameter effects, as well as an intelligent mode throughout the entire lifecycle, the intelligent brain of trains will be constructed, enabling trains to self-perceive, self-organize, and self-decide. In addition, new transportation systems such as unmanned driving, remote driving, and integrated aerial-ground transportation will continue to emerge and gradually enter the daily lives of the public.

(Translated by ZHANG Liman)